

A REVIEW ON BIOLOGICAL ADVANTAGES OF PIGEONPEA INTERCROPPING INFLUENCED BY DIFFERENT CROPPING GEOMETRIES

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ABSTRACT

The greatest challenge of the 21st century in many developing countries are to produce more and more basic necessities namely food, fodder, fuel and fibre for ever increasing human and animal population from the limited available land. The availability of land for agriculture is shrinking every day as it is increasingly utilized for non-agricultural purposes. Under this situation, one of the important strategies to increase agricultural output is development of high intensity cropping systems including intercropping system which involves biotic and abiotic stress resistant, soil building, protein rich and oil producing crops. Cropping systems found to have more advantage over sole cropping systems as income wise and soil health wise.

KEYWORDS: Challenge, Agriculture, Cropping System, Biotic, Abiotic Stress

INTRODUCTION

The productivity of a cropping system is mainly determined by the efficiency of the component crops in utilization of resources. This depends not only on the individual main and component crops of the system, but also time and space dimension (Willey *et al.*, 1981). It is a common knowledge and observation that when a tall main crop like pigeonpea intercropped with a short stature legume component like greengram, the beneficial effects accrue both from the point of better utilization of aerial atmosphere and from the stand point of improved utilization of underground resources. Therefore, the overall productivity of pigeonpea based system depends partly on the efficiency of pigeonpea crop itself and partly on how well pigeonpea fits with greengram and vice-versa. So the overall productivity of the intercropping of legumes relies on the main crop as well as compatibility with other crops. A system to be productive has to ensure the complementarity resource use pattern among the main and component crops. Inclusion of legumes, made better use of resources such as light, nutrient and water by the component crops in intercropping system.

In recent years, it is often recognized that intercropping system can produce higher yield than sole cropping, but there can be problems in assessing the degree of yield advantages. Yet, such an assessment is essential to determine whether a given intercropping combination is indeed better than sole cropping and whether, within that combination one cropping system is better than other. There are number of ways to ensure that intercropping advantages are accurately assessed and most common method is by calculating land equivalent ratio (LER) and area time equivalent ratio (ATER) and equivalent yield. Spatial and temporal identification of cropping is the need of the day to keep the pace between food grain production and burgeoning population in a densely populated country like India. Though intercropping is an age-old practice, it has attracted worldwide attention owing to the yield advantages (Willey, 1979), if the crops selected are

compatible and grown with scientific technology.

Intercropping involves the scientific management of compatible crops and genotypes so as to minimise the complex interspecific, intervarietal and interplant interactions. To achieve this, the competition between component crops may be minimized by selecting crops of different rooting pattern, growth habit and maturity groups having complementary effect, and by adjusting plant geometry, planting time, population levels and other agronomic practices in such a way which enables to use the production resources efficiently and enhance productivity per unit area and time.

Pigeonpea as soil ameliorant is known to provide several benefits to soil in which it is grown. The seed, pod and the leaf are used for human and livestock nutrition and the crop generally enhances soil fertility through leaf litter and biological nitrogen fixation (Snapp *et al.*, 2003). The deep penetration and lateral spread of root system in the soil profile enables the crop to tolerate drought. It can adapt to a wide range of soils and its deep root system enables the crop to utilize the moisture and nutrients optimally. Its tap root system is reported to break the plough pans, thus often called as "biological plough". Extensive ground cover by pigeonpea prevents soil erosion by wind and water, encourages infiltration of rain water and smothers the weeds.

When pigeonpea is grown as a sole crop, it is relatively inefficient because of its slow initial growth rate and low harvest index (Willey *et al.*, 1980); therefore it is grown as intercrop, which helps in efficient utilization of available resources for enhancing the productivity and profit. Pigeonpea is suitable for inter-cropping with different crops like cotton, sorghum, pearl millet, greengram, blackgram, maize, soybean and groundnut for increasing production and maintaining soil fertility. The initial slow growth rate and deep root system of pigeonpea offers a good scope for intercropping with fast growing early maturing and shallow rooted crops (Ramamoorthy *et al.*, 2004). Pigeonpea has more advantages when it is grown under intercropped situation.

Land Equivalent Ratio

Land equivalent ratio reflects the advantage of intercropping over sole cropping system. The obvious reason for large yield advantage in intercropping system is that the component crops differed in their use of natural resources and utilized them more efficiently resulting in higher yields per unit area than that produced by their sole crops.

Subbareddy and Venkateshwarlu (1992) reported that among the intercropping systems, maximum LER values were recorded with sesame followed by black gram intercropping in pigeonpea as compared with okra under all the planting patterns. Itnal *et al.* (1994) at Bheemarayanagudi recorded the highest LER (1.66) in intercropping of blackgram + pigeonpea in 3:1 row proportion followed by the same row proportion of greengram + pigeonpea (1.65). Among the oilseeds, pigeonpea + sesame, among the pulses pigeonpea + black gram and among cereals pigeonpea + sorghum were found to be best intercropping systems in terms of pigeonpea equivalent yield and land equivalent ratio (Singh and Singh, 1994).

Rani and Kodandaramaiah (1997) found that pigeonpea + soybean in 2:4 row proportion recorded highest pigeonpea equivalent yield, land equivalent ratio and benefit cost ratio. Jana *et al.* (2000) studied the efficiency of intercropping maize (*Zea mays*) and common bean. Higher LER and LER + ATER average obtained under intercropping system than monocropping.

In a study involving pigeonpea, groundnut and finger millet intercropping system, higher land equivalent ratio was recorded with intercropping of finger millet + pigeonpea systems (Maitra *et al.*, 2000). Srinivasulu *et al.* (2000) reported that the LER was higher with pigeonpea + sesame intercropping systems, irrespective of the planting pattern of pigeonpea.

Omprakash and Bhushan (2000) found that pigeonpea/castor + greengram intercropping showed the highest LER (1.62 and 1.61) and pigeonpea/castor + pearl millet the lowest LER (1.16). Pigeonpea and castor based intercropping systems recorded 16-61 and 16-62 per cent higher LER values, respectively than sole cropping of component crops. Owere *et al.* (2001) recorded higher LER up to 1.30 and 1.29 in finger millet + pigeonpea and sorghum + pigeonpea intercropping at 2:2 row ratio.

The total LER for yield and growth ranged between 1.06 to 1.58 and 1.38 to 1.86, respectively showing yield and growth advantage of intercropping of maize and bean. Concerning radiation and water use, the intercropping system had higher water use efficiency and radiation use efficiency than their respective sole cropping (Tsubo *et al.*, 2003).

Chaudhary and Thakur (2005) conducted the experiment on sandy loam soil and found that intercropping affected the grain yield of pigeonpea and component crops but it increased the total productivity in terms of pigeonpea equivalent. Highest land equivalent ratio of 1.55 was recorded under pigeonpea + maize followed by pigeonpea + blackgram (1.52).

Birbal Sahu (2006) reported in intercropping of maize + pigeonpea (2:2) recorded the highest LER (1.59) followed by maize + pigeonpea in 1:1 row ratio (1.56). Egbe and Adeyemo (2006) stated that the LER values are greater than 1.0 in maize/pigeonpea intercropping. Pramod *et al.* (2006) reported that the intercropping of soybean + pigeonpea with 3:1 row proportion produced LER of 1.38.

Rao *et al.* (2009) conducted an experiment during 2005–07 to study the effects of intercrop row ratio and nitrogen on sorghum + greengram which resulted in highest land equivalent ratio (1.32) and price equivalent ratio (1.23). Padhi *et al.* (2010) stated that the finger millet + pigeonpea at 2:4 row ratio appeared to be compatible, biologically efficient and economically viable with significantly higher land equivalent ratio (1.42).

Area Time Equivalent Ratio

Intercrop advantage estimated by land equivalent ratio method sometimes misleading because the conceptual basis in which the monoculture versus intercrop comparisons were made is incomplete. In LER time factor is not taken into consideration. Area Time Equivalent Ratio will correct this conceptual inadequacy in LER and enable to assess land use efficiency along with time use efficiency in crop mixtures (Hiebsch and McCollum, 1987).

Hulihalli (1987) at Dharwad recorded significantly higher ATER (1.23) under intercropping system of pigeonpea with groundnut when compared to sole crop of either groundnut or pigeonpea (1.0). Row proportions, pigeonpea population levels and their interactions did not influence the ATER significantly. Intercropping of pigeonpea and sunflower in 2:1 row proportion with 67:33 per cent recommended plant population of pigeonpea and sunflower, respectively recorded the highest yield advantage of 40 per cent and maximum ATER value of 0.94 to 1.21 compared to other intercropping treatments (Biradar *et al.*, 1988).

The ATER realized from intercropped pigeonpea (1.09) was significantly higher when compared to sole pigeonpea (1.0) (Pujari, 1996). This indicates that, not only the efficient use of land but also efficient use of time to the

extent of nine per cent. Pigeonpea intercropped with soybean produced ATER of 1.13 and it was decreased to 1.06 when intercropped with greengram, which may be due to higher yielding potential of soybean than greengram. Among row proportions, ATER under 2:2 (1.14) and 1:2 (1.11) were significantly higher as compared to 1:1 (1.06) row proportion.

Patil (2003) reported that among intercropping treatments tried, intercropping of little millet + pigeonpea in 4:2 row proportion was found better on the basis of yield and yield advantage (assessed in terms of LER and ATER). Padhi *et al.* (2010) reported that intercropping of pigeonpea with finger millet in 2:4 ratio appeared to be compatible, biologically efficient and significantly higher area time equivalent ratio (1.38). Arjun Sharma and Guled (2012) reported that pigeonpea + greengram (1:2) intercropping system under set-furrow with the application of vermicompost @ 2.5 t ha⁻¹ recorded significantly higher ATER (1.55) over other intercropping systems.

Pigeonpea Equivalent Yield

Crop equivalent yield is an important index in assessing the performance of different crops under a given circumstance. Based on the price structure, economic yield of component crops is converted into base crop yield *i.e.*, pigeonpea equivalent yield. Pigeonpea equivalent yield showed marked differences due to inclusion of a short legume like greengram.

Ahmed (1991) indicated that the pigeonpea equivalent yield from intercropping of pigeonpea and groundnut in various row proportions were higher as compared to sole pigeonpea. Dubey *et al.* (1991) reported that, the pigeonpea equivalent was increased by about 33 per cent when pigeonpea was intercropped with soybean or blackgram in 1:1 row proportion over sole pigeonpea.

Goyal *et al.* (1991) opined that when total production was considered, the intercropping system of pigeonpea + blackgram recorded higher pigeonpea equivalent (21.6 q ha⁻¹) followed by pigeonpea + greengram (19.3 q ha⁻¹) and pigeonpea + sesame (19.1 q ha⁻¹) intercropping. Prasad and Srivastav (1991) reported that there was an increase of 50 per cent pigeonpea equivalent yield by introducing one row of soybean in between two rows of pigeonpea spaced at 60 cm apart. Dharam Singh and Singh (1992) reported 27 per cent increase in pigeonpea equivalent yield by introducing one row of greengram between two rows of pigeonpea as compared to sole pigeonpea.

The higher pigeonpea equivalent yield in sunflower and pigeonpea intercropping systems was due to additional yield obtained from the intercrop component, which enhanced the productivity of the system (Subbareddy and Venkateshwarlu, 1992). Singh and Singh (1994) indicated that, intercropping of pigeonpea + sesame and pigeonpea + groundnut recorded higher pigeonpea equivalent yield when compared to the sole crop of pigeonpea under rainfed conditions of sandy loam soil of Varanasi.

Pujari (1996) reported that intercropping of greengram/ soyabean with pigeonpea gave significantly higher pigeonpea equivalent yield than sole crop of pigeonpea. Among the intercrops, soybean produced higher pigeonpea equivalent yield. Among row proportions, 2:2 was significantly superior over 1:1 row ratio. Dwivedi and Bajpai (1997) reported a maximum pigeonpea equivalent yield of 2070 kg per ha with pigeonpea + groundnut intercropping in 1:1 row proportion on sandy loam soils of Ambikanagar (Madhya Pradesh) during kharif season.

Narkhede and Katare (1998) reported significantly higher pigeonpea equivalent yield (2446 kg ha⁻¹) in pigeonpea

+ sesame in 2:1 ratio than other treatments, except sole pigeonpea. The highest LER (1.50) was recorded in pigeonpea + sesame system under 2:1 ratio at 40 cm row to row spacing. Sharma *et al.* (1998) recorded significantly higher pigeonpea equivalent yield (2925 kg ha^{-1}), when pigeonpea was intercropped with sesame in 2:2 row proportion over 2:4 row proportion (2599 kg ha^{-1}) and sole crop of pigeonpea (2425 kg ha^{-1}). Singh and Rahman (1999) obtained the highest pigeonpea equivalent yield (2340 kg ha^{-1}) under pigeonpea + groundnut intercropping in 1:2 row proportion.

Subbian and Selvaraju (2000) revealed that growing sorghum and soybean at 3:6 row ratio recorded higher sorghum equivalent yield (3575 kg ha^{-1}) followed by sorghum + soybean at 2:4 ratio (3103 kg ha^{-1}) and sorghum + soybean at 1:2 ratio (3096 kg ha^{-1}). Among the row ratios, growing of sorghum and soybean at 3:3 ratio gave the lowest sorghum equivalent yield.

At Jalgaon, sesame + pigeonpea (3:1) intercropping system proved significantly better in terms of sesame equivalent yield (Jain *et al.*, 2001). Kedar Prasad and Yadav (2001) reported significantly higher pigeonpea equivalent yield (2061 kg ha^{-1}) in 2:2 row proportion of pigeonpea + soybean intercropping system than sole pigeonpea. Bhagat (2002) conducted an experiment to assess the feasibility of intercropping of maize under rainfed condition. The highest pigeonpea equivalent yield of 11.21 q ha^{-1} (6.72 q ha^{-1} from pigeonpea and 13.27 q ha^{-1} from maize) was obtained in paired row of pigeonpea and maize at $60 \times 30 \text{ cm}$ and was on par with maize and pigeonpea in alternate rows at $60 \times 30 \text{ cm}$.

Rathod (2002) reported that the pigeonpea equivalent yield under 1:2 (1909 kg ha^{-1}) and 1:3 (1876 kg ha^{-1}) row proportions were on par with each other. Among the cropping systems, intercropping of pigeonpea with frenchbean (2932 kg ha^{-1}) and groundnut (2406 kg ha^{-1}) gave significantly higher pigeonpea equivalent yield over sole pigeonpea and other intercropping systems. Biru Amedie Yimam *et al.* (2004) realized highest sorghum equivalent yield in sorghum intercropped with frenchbean (6419 kg ha^{-1}) followed by sorghum + soybean system.

Trials conducted under the AICRP (All India Coordinated Research Project) on pigeonpea showed that in the North West Plain Zone (NWPZ), intercropping with mungbean produced higher pigeonpea equivalent yield over the pigeonpea sole while in Central Zone (CZ), intercropping with groundnut or soybean was better and in South Zone (SZ), mungbean or urdbean intercrops showed higher pigeonpea equivalent yield (IIPR, 2003-04). Sanjaykumar *et al.* (2008) from Dehradun reported that on loamy sand soil, the mean wheat equivalent yield was higher with pigeonpea-wheat cropping sequence (8995 kg ha^{-1}).

Practical Usage

Udhaya Nandhini and Latha (2014) studied the effect of intercropping of pigeonpea with different cropping geometries on biological advantages of the cropping system (Table 1). The treatments comprised of planting geometry (row spacing of 90, 120, 150 and 180 cm at varied level of plant to plant spacing with 30, 45, and 60 cm) and different row proportions of pigeonpea + greengram (1:2, 1:3, 1:4 and 1:5) The experiment was laid out in randomized block design with three replications. Results of the study indicated that the equivalent yield (2397 kg/ha), land equivalent ratio (1.52) and area time equivalent ratio (1.15) of pigeonpea increased significantly with wider spacing of $120 \times 30 \text{ cm}$ with 1:3 row proportion. The higher LER under intercropping systems may be due to better planting geometry and spatial arrangements which might have avoided the coincidence of the peak period of growth of component crops. Pigeonpea being long duration crop with slow initial growth and deep root system did not pose any severe competition for natural resources with

greengram under different row proportions and also it adds organic matter through leaf litter production and biologically fixed nitrogen for the benefit of the intercropping systems.

On the other hand, greengram being fast growing shallow rooted crop, utilized the resources from top layer (0-30 cm) of the soil and serving as cover crop conserved soil moisture reduced soil temperature and added organic matter to the soil. This is in accordance with the findings of Omprakash and Bhushan (2000) in pigeonpea/castor + greengram.

CONCLUSIONS

Thus, it can be inferred from the above review, on the basis of agronomic as well as system advantage performance, sowing of pigeonpea in a intercropped situation with selective row proportion proved to be more productive and remunerative and this salient finding will be useful for pigeonpea growers to enhance income under irrigated conditions.

REFERENCES

1. Ahmed, S., (1991) Effect of planting pattern on pigeonpea + groundnut intercropping systems in drylands. Indian J. Agron., 36 : 351-353.
2. Arjun Sharma & Guled, M. B. (2012). Effect of set-furrow method of cultivation in pigeonpea + greengram intercropping system in medium deep black soil under rainfed conditions. Karnataka J. Agric. Sci., 25 (1): 18-24.
3. Bhagat, R. P. (2002). Intercropping of pigeonpea and maize under rainfed condition. J. Res., 14(2): 233-235.
4. Biradar, D. P., Patil, V. S. and Hunshal, C. S. (1988). Redgram and sunflower intercropping : A profitable proposition. J. Maharashtra Agric. Univ., 13: 120-121.
5. Birbal Sahu. (2006). Yield and economics of intercropping legumes in maize (*Zea maeys*) under rainfed conditions. Indian J. Agric. Sci., 76 (9): 554- 556.
6. Biru Amedie Yimam, S. M. Hiremath, B. M. Chittapur, S. L. Halikatti & V. P. Chimmad. (2004). Intercropping of grain legumes in sorghum. Karnataka J. Agric. Sci., 17(1): 22-27.
7. Chaudhary, S. K. & Thakur, S. K. (2005). Productivity of pigeonpea (*Cajanus cajan*) – based intercrops. Indian J. Agric. Sci., 75 (8): 496-497.
8. Dharamsingh and Singh, R. K. (1992) Effect of level and depth of placement of phosphorus on pigeonpea based intercropping systems under dryland conditions. Indian J. Agron., 37 : 130-134.
9. Dubey, O. P., Garg, D. C., Dixit, J. P. and Tiwari, K. P. (1991). Intercropping in short duration pigeonpea. Indian J. Agron., 36 : 253-254.
10. Dwivedi, R. K. and Bajpai, R. P. (1997). Productivity of pigeonpea based cropping systems in Northern Hills Zone of Chattisgarh. Indian J. Agron., 42 : 50-52.
11. Goyal, S. N., Patel, N. L., Patel, N. M. and Ahlawat, R. P. S. (1991) Intercropping studies in pigeonpea under rainfed conditions. Indian J. Agron., 36(1) : 49-51.

12. Hiebsch, C. K. & McCollum, R. E. (1987). Area time equivalent ratio: A method of evaluating the productivity of intercrops. *Agron. J.*, 79: 15-22.
13. Hulihalli, U. K. (1987). Studies on row proportion and plant population of groundnut and pigeonpea under intercropping system in transition tract of Dharwad. M. Sc. (Agri.) Thesis, Univ. Agric. Sci., Dharwad, Karnataka, India.
14. IIPR. 2003-2004. All India Coordinated Research Project on Pigeonpea. Annual Report 200.
15. Itnal, C. J., Nagalikar, V. P. Basavaraj, P. K. and Lingaraju, B. S. (1994). Intercropping of greengram and blackgram in pigeonpea. *Karnataka J. Agric. Sci.*, 7 : 69-71.
16. Jain, H. Deshmukh, C., M. R. & Duhoon. (2001). Studies on fertilizer management in sesame based intercropping system under rainfed conditions in different agro ecosystems. *J. Oilseeds Res.*, 18(2): 176-177.
17. Jana, D. C., Barriga, B. P. Krarvp, H. A. & Fuentes, P. R. (2000). Efficiency of intercropping maize (*Zea mays*) and common bean (*Phaseolus vulgaris*). *Agro-Sur.*, 28(1): 71-80.
18. Kedar Prasad & Yadav. C. B. (2001). Intercropping studies of pigeonpea and soybean with varying phosphorus doses under rainfed conditions of central Uttar Pradesh. *Crop Res.*, 21: 290-294.
19. Maitra, S., Ghosh, D. C. Sounda, G. Jana, P. K & Roy, D. K.. (2000). Productivity, competition and economics of intercropping legumes in finger millet at different fertility levels. *Indian J. Agric. Sci.*, 70(9): 824-828.
20. Narkhede, W. N. & Katare, R. A. (1998). Studies on pigeonpea and sesame intercropping system. *J. Maharashtra Agric. Univ.*, 23: 330-331.
21. Omprakash & Bhushan, L. S. (2000). Productivity and economics of pigeonpea (*Cajanus cajan*) and castor (*Ricinus communis*) based intercropping systems. *Indian J. Soil Conserv.*, 28(2): 147-150.
22. Owere, L., Rubaihayo, P. R. Osiru, D. S. Silim, S. M. & Mergeat. G. (2001). Cereal pigeonpea intercropping systems, status and potential of pigeonpea in eastern and southern Africa. In: Proceedings of a Regional Workshop, Nairobi, Kenya, 12-15th September, 84-90.
23. Padhi, A. K., Panigrahi, R. K. & Jena. B. K.. (2010). Effect of planting geometry and duration of intercrops on Performance of pigeonpea-finger millet intercropping systems. *Indian J. Agric. Res.*, 44(1): 43-47.
24. Patil, N. B. (2003). Studies on intercropping of little millet with pigeonpea on Alfisols of Dharwad. M. Sc. (Agri.) Thesis. Univ. Agric. Sci., Dharwad, Karnataka, India.
25. Prasad, K. and Srivastav, V. C. (1991). Pigeonpea and soybean intercropping systems under rainfed situation. *Indian J. Agric. Sci.*, 61 : 243-246.
26. Pujari, B. T. (1996). Pigeonpea based intercropping system in Vertisols of Northeastern Dry Zone of Karnataka. Ph. D. Thesis, Univ. Agric. Sci., Dharwad, Karnataka, India.
27. Rani, B. P. & Kodandaramaiah, D. (1997). Effect of row combinations of soybean (*Glycine max*) and pigeonpea (*Cajanus cajan*) in rainfed black soils of Krishna Godavari zone of Andhra Pradesh. *Indian J. Agron.*, 42: 56-58.

28. Rao, S. S., Regar, P. L. Jangid, B. L. & Chand, K. (2009). Productivity and economics of sorghum (*Sorghum bicolor*) and greengram (*Phaseolus radiata*) intercropping system as affected by row ratio and nitrogen in arid fringes. *The Indian J. Agric. Sci.*, 79(2): 101-105.
29. Rathod, P. S. (2002). Intercropping studies in pigeonpea with short duration pulses and oilseeds. M. Sc. (Agri.) Thesis, Univ. Agric. Sci., Dharwad, Karnataka, India.
30. Sanjaykumar, A., Singh, N. S. Rana, S & Pannan, G. S. (2008). Production potential, profitability and sustainability of different wheat (*Triticum aestivum*) based cropping systems in semi-arid region of Uttrakhand. *Indian J. Agric. Sci.*, 78(3): 248-250.
31. Sharma, P. B., Raghuvanshi, P. S. & Ambawatia, G. R. (1998). Intercropping sesame with pigeonpea under varying sowing dates. *J. Oilseeds Res.*, 15(2): 58-63.
32. Singh, R. A. and Singh, A. K. (1994) Comparative performance of different intercropping systems with pigeonpea under rainfed conditions of Vindhya region. *Indian J. Agron.*, 39(4): 613-615.
33. Singh, R. S. & Rahman. A (1999). Economic feasibility of pigeonpea based intercropping systems in Chotanagpur plateau. *J. Res.*, 11: 27-30.
34. Srinivasulu, K., Singh, R. P. & Madhavi, K. (2000). Performance of rainfed pigeonpea based intercropping systems under varying planting patterns. *Crop Res.*, 20: 56-61.
35. Subbareddy, G. and Venkateshwarlu, S. (1992) Effect of planting pattern on yield and moisture use efficiency in sunflower – pigeonpea intercropping system. *Indian J. Agron.*, 37(4): 659-665.
36. Subbian, P. & Selvaraju, R. (2000). Effect of row ratio on sorghum (*Sorghum bicolor*) + soybean (*Glycine max*) intercropping system in rainfed Vertisols. *Indian J. Agron.*, 45: 526-529.
37. Tsubo, M., S. Mukhala, Ogindo, H. P. & Walker, S. (2003). Productivity of maize-bean intercropping in a semi-arid region of South Africa. *Water-SA*, 29(4): 381-388.
38. Udhaya Nandhini, D & Latha. K. R. (2014). LTR and Yield Advantages of Pigeonpea at Different Cropping Geometry Under Intercropped Situation. *Trends in Biosciences* 7(22): 3733-3735
39. Willey, R. W. (1979). Intercropping - its importance and research needs. I. Competition and yield advantage. *Field Crops Abstract*, 32: 1-10.
40. Willey, R. W., Rao, M. R., Reddy, M. S. & Natarajan, M. (1981). Cropping systems with sorghum. In: Proceedings of International Symposium on Sorghum ‘Sorghum in the Eighties’, 2-7 November, International Crops Research Institute for the Semi-Arid Tropics, Patancheru, Hyderabad, India, pp. 449- 477.

APPENDICES

Table 1: Effect of Planting Geometry and Row Proportions on Pigeonpea Light Transmission Ratio, Equivalent Yield, Land Equivalent Ratio (LER) and Area Time Equivalent Ratio (ATER) of Pigeonpea + Greengram Intercropping System

Treatments	Equivalent Yield (Kg Ha ⁻¹)	Land Equivalent Ratio	Area Time Equivalent Ratio
T ₁ - Pigeonpea (90 x 30 cm) + Greengram (1:2)	1831	1.28	0.98
T ₂ - Pigeonpea (90 x 45 cm) + Greengram (1:2)	1865	1.29	0.97
T ₃ - Pigeonpea (90 x 60 cm) + Greengram (1:2)	2142	1.47	1.11
T ₄ - Pigeonpea (120 x 30 cm) + Greengram (1:3)	2397	1.52	1.15
T ₅ - Pigeonpea (120 x 45 cm) + Greengram (1:3)	2209	1.46	1.09
T ₆ - Pigeonpea (120 x 60 cm) + Greengram (1:3)	2004	1.36	1.01
T ₇ - Pigeonpea (150 x 30 cm) + Greengram (1:4)	1717	1.40	1.05
T ₈ - Pigeonpea (150 x 45 cm) + Greengram (1:4)	1598	1.40	1.05
T ₉ - Pigeonpea (150 x 60 cm) + Greengram (1:4)	1441	1.30	0.94
T ₁₀ - Pigeonpea (180 x 30 cm) + Greengram (1:5)	1602	1.50	1.12
T ₁₁ - Pigeonpea (180 x 45 cm) + Greengram (1:5)	1484	1.40	1.03
T ₁₂ - Pigeonpea (180 x 60 cm) + Greengram (1:5)	1440	1.37	0.96
SED	60.77	0.05	0.04
CD (P=0.05)	126.02	0.10	0.08

